U.S. Fish & Wildlife Service

Abundance and Run Timing of Adult Chinook Salmon in the Funny River, Kenai Peninsula, Alaska, 2006

Alaska Fisheries Data Series Number 2007-2

Kenai Fish and Wildlife Field Office
Kenai, Alaska
February, 2007

The Alaska Region Fisheries Program of the U.S. Fish and Wildlife Service conducts fisheries monitoring and population assessment studies throughout many areas of Alaska. Dedicated professional staff located in Anchorage, Juneau, Fairbanks, Kenai, and King Salmon Fish and Wildlife Offices and the Anchorage Conservation Genetics Laboratory serve as the core of the Program's fisheries management study efforts. Administrative and technical support is provided by staff in the Anchorage Regional Office. Our program works closely with the Alaska Department of Fish and Game and other partners to conserve and restore Alaska's fish populations and aquatic habitats. Additional information about the Fisheries Program and work conducted by our field offices can be obtained at:

http://alaska.fws.gov/fisheries/index.htm

The Alaska Region Fisheries Program reports its study findings through two regional publication series. The **Alaska Fisheries Data Series** was established to provide timely dissemination of data to local managers and for inclusion in agency databases. The **Alaska Fisheries Technical Reports** publishes scientific findings from single and multi-year studies that have undergone more extensive peer review and statistical testing. Additionally, some study results are published in a variety of professional fisheries journals.

Alaska Fisheries Data Series Number 2007-2, February 2007
U.S. Fish and Wildlife Service

Abundance and Run Timing of Adult Chinook Salmon in the Funny River, Kenai Peninsula, Alaska, 2006

Kenneth S. Gates and Douglas E. Palmer

Abstract

A fish weir equipped with an underwater video system was installed and operated in the Funny River during 2006 to collect abundance, run timing, and biological information on adult Chinook salmon *Oncorhynchus tshawytscha*. A total of 2,779 Chinook salmon were counted past the Funny River weir between 16 May and 2 October. Other species enumerated included 2,537 Dolly Varden *Salvelinus malma*, 1,909 coho salmon *O. kisutch*, 428 pink salmon *O. gorbuscha*, 158 sockeye salmon *O. nerka*, 4 chum salmon *O. keta*, 72 rainbow trout *O. mykiss*, and 14 whitefish *Coregonus* spp. Peak weekly passage of Chinook salmon occurred between 11 and 17 June. Age, sex, and length (ASL) and genetic data were collected from 183 Chinook salmon. Sex of Chinook salmon was also determined by examining recorded video footage. Females comprised 31% (ASL and video combined) of the escapement. The average length of male and female Chinook salmon was 693 mm and 832 mm, respectively. Ages of Chinook salmon determined from scale analysis ranged between 1.1 and 1.4. Females were comprised of only two age classes, 1.3 and 1.4.

Introduction

The Kenai River supports one of the largest recreational fisheries for Chinook salmon *Oncorhynchus tshawytscha* in Alaska (Nelson et al. 1999). The popularity of this sport fishery requires intensive management and research programs focusing on Kenai River Chinook salmon stocks. The fishery is managed as two distinct runs; fish entering the river during May and June are managed as the early-run, while those entering the river after 30 June are managed as the late-run. Early-run fish are harvested primarily by sport anglers in the Kenai River, whereas late-run fish are harvested by commercial, sport, and personal use fisheries. Chinook salmon returning to the Funny River are considered part of the early-run. The number of early-run Chinook salmon returning to the Kenai River has been estimated since 1987 using sonar located at river kilometer (rkm) 13. Sonar escapement estimates for the early-run have ranged from 7,162 to 27,080 fish between 1986 and 2004 (Pappas and Marsh 2004). These estimates provide the basis for estimating spawning escapement and implementing the management plan that regulates harvest in the in-river sport fishery.

Sport harvest of early-run Chinook salmon occurs below Skilak Lake during May and June. Harvest also occurs, while not in great numbers, in three other fisheries: the Central Cook Inlet marine sport fishery, the Upper Subdistrict set gillnet (Eastside set net) commercial fishery, and an in-river educational fishery, (McKinley et al. 2002). Sport harvest of early-run Chinook salmon is monitored by the Alaska Department of Fish and Game (Department) through an in-river creel survey between the Warren Ames Bridge (rkm 8) and the Soldotna Bridge (rkm 32) and through the Statewide Harvest Survey between the Soldotna Bridge and Skilak Lake (rkm

Authors: Kenneth S. Gates and Douglas E. Palmer are fisheries biologists with the U.S. Fish and Wildlife Service. The authors can be contacted through the Kenai Fish and Wildlife Field Office, P.O. Box 1670, Kenai, Alaska 99611; or Kenneth_Gates @fws.gov and Douglas_Palmer@fws.gov.

80). Annual sport harvest has ranged between 899 and 15,209 fish and has averaged 5,963 fish since 1986 (Gamblin et al. 2004; Pappas and Marsh 2004; Larry Marsh, Alaska Department of Fish and Game, personal communication). On average, about 73% of the sport harvest occurs below the Soldotna Bridge. Much of the annual variation in harvest since 1986 can be explained by fluctuations in run strength and in-season liberalization or restriction of the sport fishery.

Radio telemetry studies conducted during the early 1980's and 1990's provide some insight regarding the migratory behavior and spawning destinations of the early-run Kenai River Chinook salmon. Bendock and Alexandersdottir (1991 and 1992) found that the majority of early-run fish spawned in larger tributaries such as the Killey (42 to 64%) and Funny (20 to 21%) rivers. The remainder of the radio-tagged fish spawned in smaller tributaries (6 to 10%) and the mainstem Kenai River (9 to 28%). Similarly, Burger et al. (1985) found that 56% spawned in the Killey River, 18% in the Funny River, 18% in the mainstem, and 5% in other Kenai River tributaries between 1980 and 1982. Peak spawning times, although subjective based on small sample sizes, are thought to occur between 12 and 22 July in the Funny River (Burger et al. 1985). Furthermore, many Chinook salmon destined for the Funny River and other tributaries have a tendency to mill for long periods prior to spawning events. Burger et al. (1983) identified one radio tagged Chinook salmon that milled near the mouth of the Funny River between 1 and 28 July before entering to spawn. Bendock and Alexandersdottir (1992) observed similar behavior and noted that early-run Chinook salmon mill for extended periods in the mainstem Kenai River at or below their destination confluence. Funny River spawners particularly exhibited this behavior along the south bank of the Kenai River between rkm 45 and 48. Similar milling behaviors have been observed by Liscom et al. (1978) for Columbia River Chinook salmon tributary spawners, which can spend 6 to 38 days near a confluence before entering to spawn. Because early-run Chinook salmon have a tendency to mill in the mainstem Kenai River near spawning tributaries into late July and slowly exit areas open to sport fishing, some early-run fish are susceptible to harvest throughout most of July when the sport fishery is targeting late-run fish (Bendock and Alexandersdottir 1992).

Regulations pertaining to early-run Chinook salmon change frequently to address biological issues. For example, a slot limit protecting fish between 44 and 55 inches, typically four and five year old ocean fish, was enacted in 2002 to address the biological concern of fewer large and old fish present in the in-river sport fishery. In January 2005, an optimum escapement goal (OEG) range of 5,300 to 9,000 fish was adopted by the Alaska Board of Fisheries. The new OEG replaced the previous biological escapement goal (BEG) of between 7,200 and 14,400 early-run Chinook salmon. With the OEG, restrictions and liberalizations in the fishery would take place only when the lower limits are not met or the upper limits are exceeded. The effects of this change are unknown but most likely would create a more predictable sport fishery by reducing restrictions on the in-river sport fishery and allowing for an increase in harvest. For example, during the first year of management using an OEG, the in-river sport fishery was liberalized on 18 June allowing the use of bait from the mouth of the Kenai River upstream to 100 yards below the mouth of the Moose River (Alaska Department of Fish and Game Emergency Order Number 2-KS-1-10-05). Restricting or liberalizing the fishery early or late in the run could increase the possibility of disproportionately harvesting early or late arriving early-run Chinook salmon. Because information is limited about run timing of specific tributary populations, disproportionately harvesting early or late in the run could be detrimental to smaller populations of early-run Chinook salmon (McKinley et al. 2002).

Stakeholders demand high levels of accuracy and repeated validation of ongoing research programs and despite the current efforts several issues remain to be resolved. For instance, the degree of overlap in the run-timing of tributary- and mainstem-spawning Chinook salmon is not known, nor is the abundance of tributary stocks which are a dominant component of the early-run. This need for more detailed information prompted the development of a cooperative study between the Service and Department. Our study focused on early-run Chinook salmon returning to the Funny River. By using a resistance board weir in conjunction with an underwater video system, we were able to (1) enumerate adult Chinook salmon entering the Funny River, (2) determine the run timing of Chinook salmon entering the Funny River, (3) estimate the age, sex and length composition of the Chinook salmon escapement in the Funny River, and (4) collect genetic tissue samples from 183 Chinook salmon that spawned in the Funny River as part of a larger watershed based study. Information pertaining to the run size, timing, age, sex, and genetic composition of Chinook salmon returning to the Funny River will provide a better understanding of tributary spawners and assist managers in refining existing management strategies.

Study Area

The glacially turbid Kenai River originates in Cooper Landing at the outlet of Kenai Lake and flows 132 km before entering Cook Inlet (Figure 1). The watershed consists of mountains, glaciers, forests, and the Kenai Peninsula's second and third largest lakes, Skilak and Kenai lakes. The Funny River, one of several tributaries, enters the Kenai River at rkm 49 (60° 29.47'N and 150° 51.92'W; WGS84). The Funny River drains approximately 218 km^2 and most of the watershed lies within the Kenai National Wildlife Refuge. The river channel near the weir location can be described as having moderate gradient, moderate to high sinuosity, and predominately coarse gravel substrate. Vegetation along the banks and throughout the flood plain consists primarily of willow and alders with some stands of spruce (Moser 1997). Water depth varies throughout the channel but is usually deepest near the outside bends and shallowest through the crossovers.

Methods

Weir and Video Operations and Design

The Service and Department operated a resistance board weir and video system in the Funny River approximately 0.8 km above the intersection of Funny River Road and Funny River from 16 May through 2 October.

The weir was constructed using specifications outlined by Tobin (1994) with minor changes to some materials, panel width, and resistance boards. The resistance board weir design works well in systems that can experience higher seasonal discharges such as the Funny River. Other than weir maintenance and biological sampling, the weir was unmanned and outfitted with a video system. The weir was configured to pass fish near the deepest part of the channel through a fish passage panel. Each weir panel was attached to a steel rail anchored to the river bottom. A live trap facilitated biological sampling and was attached to the front of the fish passage panel. The video system, consisting of a sealed camera box and fish passage chute, was attached to the front of the live trap.

Setup and design of the video system was similar to that used by Gates and Palmer (2006a and 2006b) in Crooked and Nikolai creeks during 2005 and 2006 and Anderson et al. (2004) in Big

Creek during 2003. One underwater video camera was located inside a sealed video box attached to the fish passage chute. The video box was constructed of 3.2-mm aluminum sheeting and was filled with filtered water. Safety glass was installed on the front of the video box to allow for a scratch-free, clear surface through which images were captured. The passage chute was constructed from aluminum angle and was enclosed in plywood isolating it from exterior light. The backdrop of passage chute from which video images were captured could be adjusted laterally to minimize the number of fish passing through the chute at one time. The backdrop could also be easily removed from the video chute when dirty and replaced with a new one. All video images were recorded on a removable 120 gigabyte hard drive at 20 frames-per-second using a computer-based DVR. Fish passage was recorded 24 hours per day seven days each week. Stored video files were reviewed daily. The video box and fish passage chute were artificially lit using a pair of 12-volt underwater pond lights. Pond lights were equipped with 20-watt bulbs which provided a quality image. The lights provided a consistent source of lighting during day and night hours. The DVR was equipped with motion detection to minimize the amount of blank video footage and review time. Appendix 1 contains a complete list of video equipment.

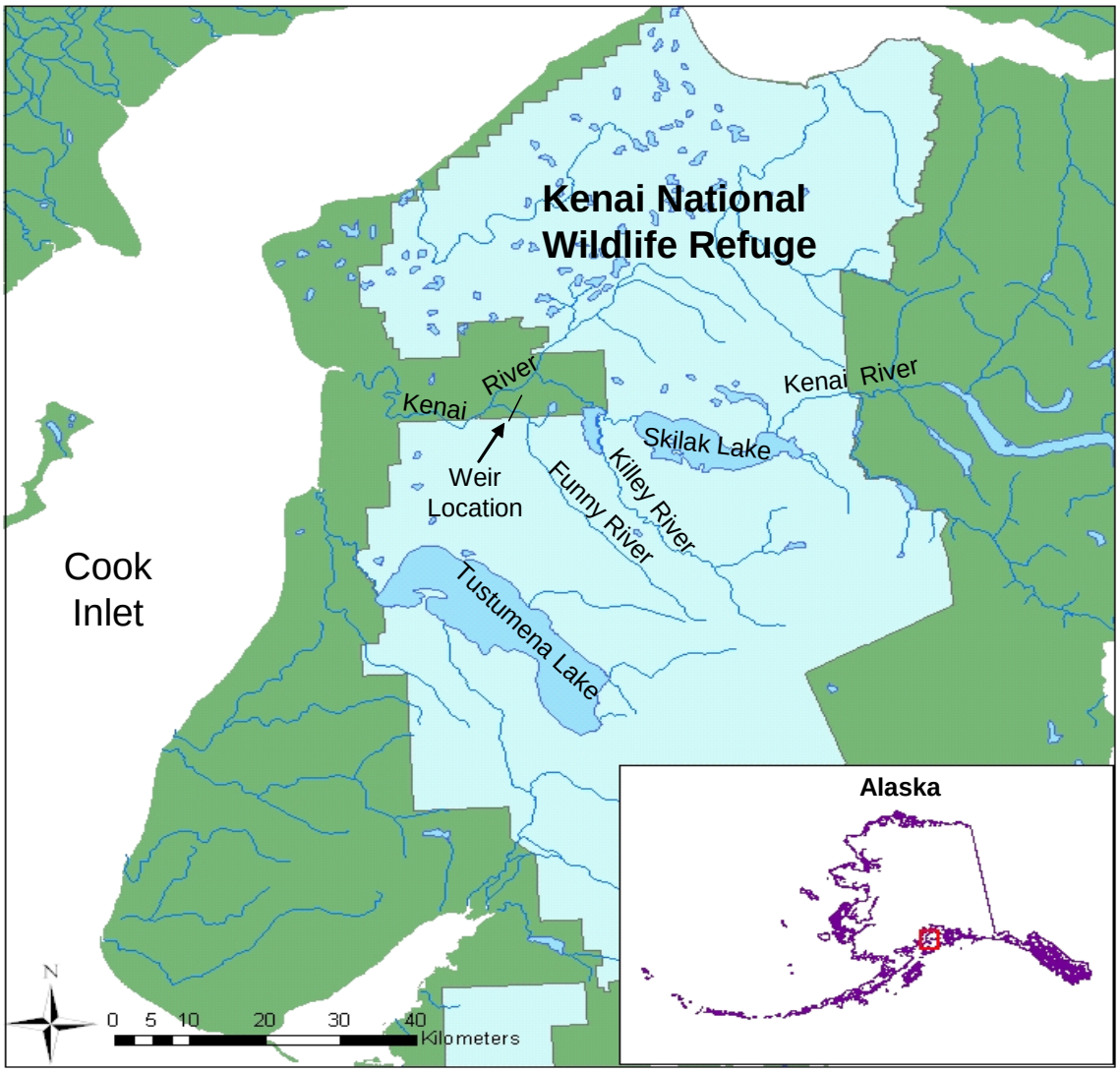

FIGURE 1. —Map of the Kenai River watershed showing weir location on Funny River.

Biological Sampling

Data on fish age, sex, and length (ASL) were collected using a temporally stratified sample design (Cochran 1977). Sampling effort was divided into strata. Each stratum is a calendar week consisting of seven days, in which sampling took place in a 2-3 day time period. Samples were taken in as minimal amount of time as possible and are considered a "snap shot" sample (Geiger et al. 1990).

Sampling consisted of sex determination, length measurements, and scale and tissue collections. Sex was determined by observing external characteristics. Length measurements were taken from the mid-eye to fork length to the nearest 5 mm. Scales were removed from the preferred area using methods described by Mosher (1968) and Koo (1962). The preferred area is located on the left side of the fish, two scale rows above the lateral line and on a diagonal from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin. Three scales were taken from each Chinook salmon, mounted on gummed cards, pressed on acetate to make an impression and then viewed with a microfiche reader by the Department. Scale analysis and reporting utilize methods described by Mosher (1969). Age determination includes the number of years spent in freshwater as a juvenile and the number of years spent in saltwater as an adult. In addition to age, sex, and length, one axillary process was removed from each Chinook salmon for genetic analysis. The axillary process was placed in a 2 mL vial and covered with denatured ethanol. Genetic tissue samples will be processed and analyzed by the Department's Gene Conservation Laboratory in Anchorage and will be summarized by the Department in a separate report.

Results

Weir and Video Operations

The weir and video system were installed on 16 May and 1 June, respectively and operated through 2 October. High water, which exceeded bank-full levels, occurred during the spring run-off from 27 to 29 May and later in the summer from 26 to 27 August. Video counts did not begin until 1 June; therefore, high water during May had no affect on the counts. This was not the case for the period of high water during August. Turbid river water reduced image quality in the video box when a log submerged a breather hose for approximately 24 h spanning two days. The image quality was restored once we removed the river water from the camera box and replaced it with filtered water on 27 August. Fish counts were incomplete during this time period.

Biological Data

Chinook salmon. —A total of 2,779 Chinook salmon were counted passing the video system at the Funny River between 1 June and 24 August (Figure 2; Appendix 2). Peak weekly passage (*N*=809) occurred between 11 and 17 June and median cumulative passage occurred on 29 June. The highest daily count (*N*=296) was on 16 June. Hatchery adipose-fin-clipped Chinook salmon from Cook Inlet watersheds other than the Kenai River comprised 0.5% (*N*=14) of the entire run.

ASL samples were collected from 183 Chinook salmon between 16 June and 27 July. Thirty-three percent (*N*=61) of the collected scales could not be aged because of regeneration or the inability to determine freshwater age. In addition, scales were not sampled from one Chinook salmon. Of the aged scales, female Chinook salmon were comprised of two age groups, ages 1.3 and 1.4. Males were comprised of four age groups, ages 1.1, 1.2, 1.3, and 1.4 (Table 1).

Overall, females averaged 832 mm in length and accounted for 21% (*N*=39) of the sample while males averaged 693 mm in length. Sex composition for the entire return of Chinook salmon (*N*=2,769, *N*=10 unsexed), including both ASL and video records, was 31% female. Sex ratios favored males throughout the entire run (Figure 3).

Other Species. —Seven additional species of fish were passed through the weir and video system in the Funny River. Passage included 2,537 Dolly Varden *Salvelinus malma*, 1,909 coho salmon *O. kisutch*, 428 pink salmon *O. gorbuscha*, 158 sockeye salmon *O. nerka*, 4 chum salmon *O. keta*, 72 rainbow trout *O. mykiss*, and 14 whitefish *Coregonus* spp. (Appendix 3). Peak weekly passage of Dolly Varden and coho salmon, the second and third most abundant fish in the Funny River, occurred between 6 and 12 August and from 27 August to 2 September, respectively. Weekly passage of all species is summarized in Table 2.

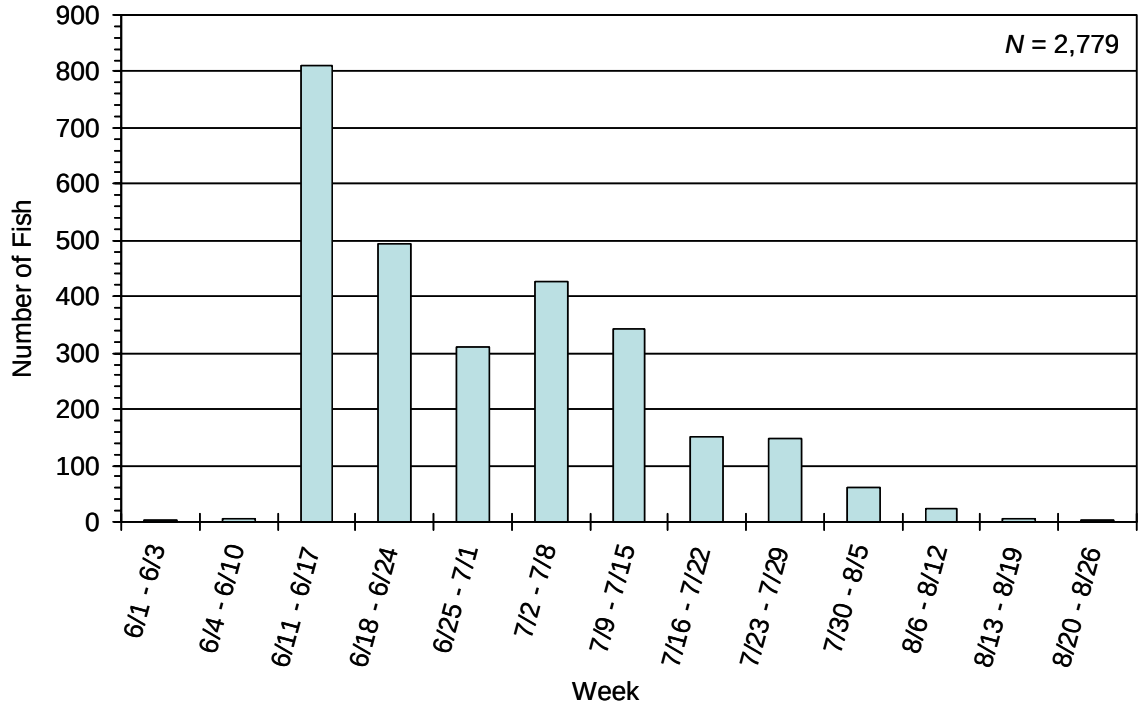

FIGURE 2. —Weekly escapement of Chinook salmon in the Funny River, Alaska, 2006. Video counts did not begin until mid-day on 1 June.

TABLE 1. —Length-at-age for Chinook salmon sampled at the Funny River weir, Alaska, 2006.

			Mid-Eye to Fork Length	
Sex	Age	*N* [a]	Mean	Range
Female	1.3	11	783	715 - 825
	1.4	13	915	845 - 1000
Total		24		
Male	1.1	8	426	345 - 555
	1.2	48	616	510 - 710
	1.3	32	789	668 - 900
	1.4	9	951	840 - 1075
Total		97		

[a] Fish with incomplete age data were omitted from this table (*N*=62).

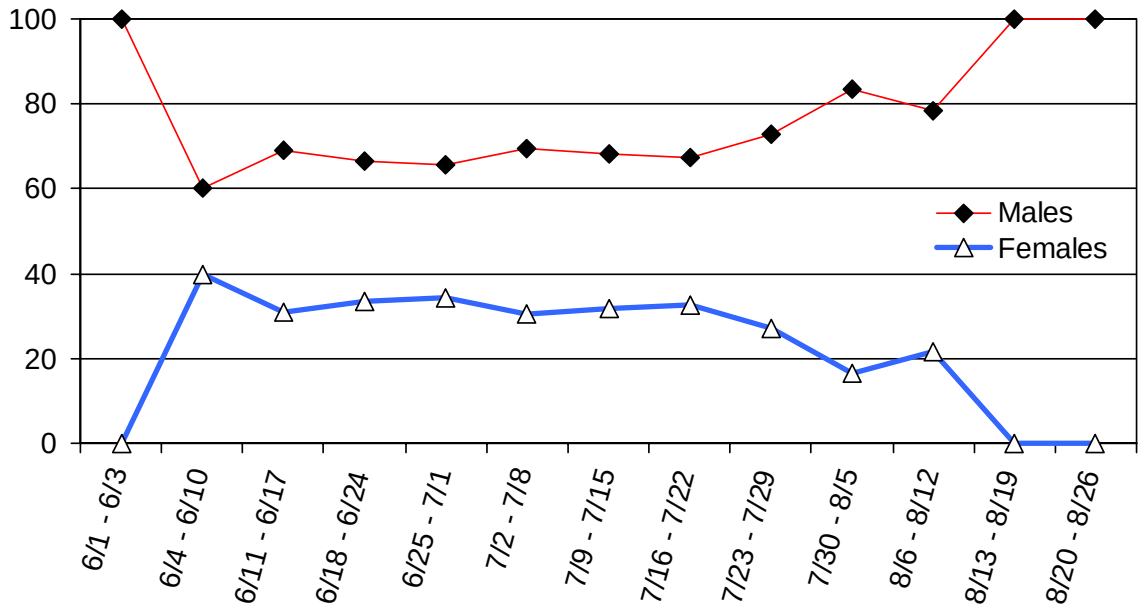

FIGURE 3. —Weekly percent of male and female Chinook salmon observed at the Funny River weir, Alaska, 2006.

TABLE 2. —Weekly passage of all species observed passing the weir and video system in the Funny River, Alaska, 2006.

Week	Rainbow Trout	Dolly Varden	Whitefish spp.	Sockeye Salmon	Pink Salmon	Chum Salmon	Chinook Salmon	Coho Salmon
6/1 to 6/3	2	6	3	1	0	0	2	0
6/4 to 6/10	4	13	2	0	0	0	5	0
6/11 to 6/17	6	7	1	2	0	0	809	0
6/18 to 6/24	8	14	1	0	1	0	494	0
6/25 to 7/1	9	11	1	3	2	0	310	0
7/2 to 7/8	10	8	0	9	10	0	428	0
7/9 to 7/15	3	24	0	10	4	0	342	0
7/16 to 7/22	6	80	1	4	6	0	151	0
7/23 to 7/29	10	290	2	8	24	0	147	0
7/30 to 8/5	2	271	2	35	78	1	60	3
8/6 to 8/12	2	521	0	38	130	0	23	36
8/13 to 8/19	2	515	1	21	62	2	6	221
8/20 to 8/26	0	177	0	10	22	0	2	311
8/27 to 9/2	2	187	0	8	12	0	0	495
9/3 to 9/9	0	171	0	4	29	1	0	337
9/10 to 9/16	3	166	0	2	41	0	0	336
9/17 to 9/23	1	60	0	0	4	0	0	142
9/24 to 9/30	1	14	0	2	3	0	0	28
10/1 to 10/2	1	2	0	1	0	0	0	0

Discussion

A total of 2,779 Chinook salmon were counted past the Funny River weir between 1 June and 24 August. We feel that these estimates of abundance accurately represent the relative run strength of Funny River Chinook salmon. We installed the weir on 16 May to ensure the enumeration of all Chinook salmon because we had no reference of their run-timing. The fish trap was installed

on 17 May to enable us to pass Chinook salmon until the video system was operational. The video system was installed on 1 June, once the video equipment became available and after spring high water subsided. Initially, we had planned to operate the weir and video system through mid-August, but later decided to operate the weir through 2 October to enumerate and collect genetic tissue samples from coho salmon.

The preliminary escapement and in-river harvest estimates between Warren Ames Bridge and Soldotna Bridge for early-run Chinook salmon during 2006 were 23,326 and 3,261, respectively (Anthony Eskelin, Alaska Department of Fish and Game, personal communication). Based on these estimates, approximately 20,065 early-run Chinook salmon escaped upstream of the Soldotna Bridge to spawn. Sport harvest of early-run Chinook salmon above the Soldotna Bridge is estimated using the Statewide Harvest Survey. This information is not yet available; however, the estimated annual harvest in this reach over an 18-year period (1986 to 2003) has averaged 1,731 fish. Using the current year escapement and harvest estimates for early-run Chinook salmon, we estimated that approximately 15% of the early-run fish entered the Funny River to spawn. This level of escapement into the Funny River was similar to the 19% observed from combining all radio tagged early-run Chinook salmon from radio telemetry studies conducted by the Service and Department in the early 1980's and 1990's (Burger et al. 1985; Bendock and Alexandersdottir 1991; Bendock and Alexandersdottir 1992).

Age, sex and length information was collected from Funny River Chinook salmon between 16 June and 27 July. We feel that our sample was not representative of the entire run based on the timing of our first sample on 16 June and the peak weekly passage which unexpectedly occurred between 11 and 17 June. Less than 2% of the run was sampled after 29% of the return had passed the weir by 17 June. In addition, age composition for female Chinook salmon in the Funny River was comprised of fewer age groups (N=2) than the age compositions determined by the Department for the in-river test net fishery (N=5) below rkm 13 and in-river creel survey (N=3) between Warren Ames and Soldotna bridges (Table 3). The female sex composition (21%) from our ASL sample was also 10% less than the overall female sex composition (31%) determined from the combination of video and ASL information. Run timing observed during 2006 will be used to determine our sampling strategy during 2007.

TABLE 3. —Kenai River early-run Chinook salmon age compositions, 2006.

	Age Groups					
Sample Location	1.1	1.2	1.3	1.4	1.5	2.3
Funny River Weir						
Male	X	X	X	X		
Female			X	X		
Inriver Test-Net Fishery						
Male	X	X	X	X	X	
Female		X	X	X	X	X
Inriver Creel Survey						
Male	X	X	X	X		
Female		X	X	X		

In conclusion, installing the Funny River weir during mid-May and successfully operating it through 2 October resulted in an accurate estimate of early-run Chinook salmon. The use of underwater video in the Funny River to estimate the abundance and run-timing of adult salmon and resident species was relatively inexpensive and reliable. We plan to continue monitoring the return of early-run Chinook salmon to the Funny River during 2007 and 2008. Weather conditions permitting in the spring of 2007, the weir may be installed and operational by 20 April to provide an assessment of run-timing, abundance, and sex composition of spawning rainbow trout. Information collected from the Funny River weir and video system will be useful in formulating future management strategies for early-run Chinook salmon and resident species in the Kenai River watershed.

Acknowledgements

Special appreciation is extended to those who participated in project setup, data collection, and video review including Waylon Marler, Dan Spencer, Robert Begich, Tim McKinley, Ty Wyatt, Tom Rhyner, and Tom Jones. The Service would also like to thank Melvin Tachick and his family for providing us access to their property to operate and store the weir and video equipment.

References

Alaska Department of Fish and Game. Emergency Order Number 2-KS-1-10-05: Bait allowed on the Kenai River downstream of the Moose River, June 18. (http://www.sf.adfg.state.ak.us/statewide/eonr/index.cfm?region=Region%202%2DSouthcentral).

Anderson, J. L., K. S. Whitton, K. K. Cornum, and T. D. Auth. 2004. Abundance and run timing of adult Pacific salmon in Big Creek, Becharof National Wildlife Refuge, 2003. U. S. Fish and Wildlife Service, King Salmon Fish and Wildlife Field Office, Alaska Fisheries Data Series Report Number 2004-7, King Salmon, Alaska.

Bendock, T. N. and M. Alexandersdottir. 1991. Hook-and-release mortality in the Kenai River Chinook salmon recreational fishery. Alaska Department of Fish and Game, Fishery Data Series Number 91-39, Anchorage, Alaska.

Bendock, T. N. and M. Alexandersdottir. 1992. Mortality and movement behavior of hooked-and-released Chinook salmon in the Kenai River recreational fishery, 1989-1991. Alaska Department of Fish and Game, Fishery Manuscript Number 92-2, Anchorage, Alaska.

Burger, C. V., D. B. Wangaard, R. L. Wilmot, and A. N. Palmisano. 1983. Salmon investigations in the Kenai River, Alaska, 1979-1981. Alaska Field Station, National Fishery Research Center, U.S. Fish and Wildlife Service, Anchorage, Alaska.

Burger, C. V., R. L. Wilmot, and D. B. Wangaard. 1985. Comparison of spawning areas and times for two runs of Chinook salmon *Oncorhynchus tshawytscha* in the Kenai River, Alaska. Canadian Journal of Fisheries and Aquatic Sciences 42: 693-700.

Cochran, W. G. 1977. Sampling Techniques, 3rd edition. John Wiley & Sons, New York.

Gamblin, M., L. E. Marsh, P. Berkhahn, and S. Sonnichsen. 2004. Area management report for the recreational fisheries of the northern Kenai Peninsula, 2000-2001. Alaska Department of Fish and Game, Fishery Management Report Number 04-04, Anchorage, Alaska.

Gates, K. S. and D. E. Palmer. 2006a. Abundance and run timing of adult steelhead trout in Crooked and Nikolai creeks, Kenai Peninsula, Alaska, 2005. U. S. Fish and Wildlife Service, Kenai Fish and Wildlife Field Office, Alaska Fisheries Data Series Number 2006-5, Kenai, Alaska.

Gates, K. S. and D. E. Palmer. 2006b. Abundance and run timing of adult steelhead trout in Crooked and Nikolai creeks, Kenai Peninsula, Alaska, 2006. U. S. Fish and Wildlife Service, Kenai Fish and Wildlife Field Office, Alaska Fisheries Data Series Number 2006-13, Kenai, Alaska.

Geiger, J.H., J.E. Clark., B. Cross, and S. McPherson. 1990. Report from the work group on sampling. Pages 3-12 *in* H.J. Geiger, and R.L. Wilbur, editors. Proceedings of the 1990 Alaska stock separation workshop. Alaska Department of Fish and Game, Division of Commercial Fisheries, Special Fisheries Report Number 2, Juneau, Alaska.

Koo, T. S. Y. 1962. Age determination in salmon. Pages 37-48 *in* T.S.Y. Koo, editor. Studies of Alaskan red salmon. University of Washington Press, Seattle, Washington.

Liscom, K. L., L. C. Stuehrenberg, and G. E. Monan. 1978. Radio tracking studies of spring Chinook salmon and steelhead trout to determine specific areas of loss between Bonneville and John Day dams, 1977. Final Report. National Marine Fisheries Service, NOAA, Seattle, Washington.

McKinley, T. R., B. E. King, J. J. Hasbrouck, and R. A. Clark. 2002. Biological issues of the Kenai River and Kasilof River early-run king salmon fisheries. Alaska Department of Fish and Game, Division of Sport Fish, Special Publication Number 02-02, Soldotna, Alaska.

Miller, J. D., D. L. Burwen, and S. J. Fleischman. 2005. Estimates of Chinook salmon abundance in the Kenai River using split-beam sonar, 2003. Alaska Department of Fish and Game, Fishery Data Series Number 05-59, Anchorage, Alaska.

Moser, E. 1997. Water Resource Inventory and Assessment, Kenai National Wildlife Refuge, 1996 stream discharge gaging data. U.S. Fish and Wildlife Service, Water Resource Branch, WRB 97-03, Anchorage, Alaska.

Mosher, K. H. 1968. Photographic atlas of sockeye salmon scales. U.S. Fish and Wildlife Service, Bureau of Commercial Fisheries, Fishery Bulletin Number 2:243-274.

Mosher, K. H. 1969. Identification of Pacific salmon and steelhead trout by scale characteristics. United States Department of the Interior, U.S. Fish and Wildlife Service, Bureau of Commercial Fisheries, Circular 317, Washington, D.C.

Nelson, D. C., D. Athons, P. Berkhahn, and S. Sonnichsen. 1999. Area management report for the recreational fisheries of the Kenai Peninsula, 1995-1997. Alaska Department of Fish and Game, Fishery Management Report Number 99-03, Anchorage, Alaska.

Pappas, G.E. and L.E. Marsh. 2004. 2004 recreational fisheries overview and historic information for the North Kenai Peninsula: Fisheries under consideration by the Alaska Board of Fisheries, January 2005. Alaska Department of Fish and Game, Fishery Management Report Number 04-17, Anchorage, Alaska.

Tobin, J. H. 1994. Construction and performance of a portable resistance board weir for counting migrating adult salmon in rivers. U. S. Fish and Wildlife Service, Kenai Fishery Resource Office, Alaska Fisheries Technical Report Number 22, Kenai, Alaska.

APPENDIX 1. —List of video equipment used to monitor Chinook salmon abundance in the Funny River, Alaska, 2006.

Item	Model #	Manufacturer	Contact
Digital Video Recorder	DVSM 4-120	Veltek International, Inc.	http://www.veltekcctv.com/
Underwater Camera	Model 10	Applied Micro Video	http://www.appliedmicrovideo.com/
Underwater Lights	Lunaqua 2 12-v	OASE	http://www.pondusa.com
External Harddrive	One Touch 250 GB	Maxtor.com	http://www.maxstore.com

APPENDIX 2. —Daily counts, ASL samples, and cumulative proportion of Chinook salmon returning to Funny River during 2006. Included are hatchery adipose-fin-clipped Chinook salmon identified during video review. Boxed areas represent the second and third quartile and median passage dates.

	Video			ASL		Ad-Clip				
Date	Male	Female	Unknown Sex	Male	Female	Male	Female	Daily Total	Daily Cumulative	Cumulative Proportion
6/1	1	0	0	0	0	0	0	1	1	0.0004
6/2	0	0	0	0	0	0	0	0	1	0.0004
6/3	1	0	0	0	0	0	0	1	2	0.0007
6/4	2	0	0	0	0	0	0	2	4	0.0014
6/5	1	2	0	0	0	0	0	3	7	0.0025
6/6	0	0	0	0	0	0	0	0	7	0.0025
6/7	0	0	0	0	0	0	0	0	7	0.0025
6/8	0	0	0	0	0	0	0	0	7	0.0025
6/9	0	0	0	0	0	0	0	0	7	0.0025
6/10	0	0	0	0	0	0	0	0	7	0.0025
6/11	1	1	0	0	0	0	0	2	9	0.0032
6/12	7	4	0	0	0	0	0	11	20	0.0072
6/13	39	15	0	0	0	0	1	55	75	0.0270
6/14	192	100	1	0	0	1	1	295	370	0.1331
6/15	53	15	0	0	0	0	0	68	438	0.1576
6/16	194	86	4	8	1	2	1	296	734	0.2641
6/17	54	21	0	5	1	0	1	82	816	0.2936
6/18	17	9	1	0	0	0	0	27	843	0.3033
6/19	20	8	1	0	0	0	0	29	872	0.3138
6/20	28	17	0	0	0	0	0	45	917	0.3300
6/21	13	3	0	0	0	0	1	17	934	0.3361
6/22	56	31	0	20	11	0	0	118	1052	0.3786
6/23	134	72	2	7	1	0	0	216	1268	0.4563
6/24	32	10	0	0	0	0	0	42	1310	0.4714
6/25	10	14	0	0	0	0	0	24	1334	0.4800
6/26	5	1	0	0	0	0	0	6	1340	0.4822
6/27	8	5	0	9	4	1	0	27	1367	0.4919
6/28	9	1	0	0	0	0	0	10	1377	0.4955
6/29	1	0	0	15	7	0	0	23	1400	0.5038
6/30	63	34	0	20	10	0	0	127	1527	0.5495
7/1	62	31	0	0	0	0	0	93	1620	0.5829
7/2	45	26	0	0	0	0	0	71	1691	0.6085
7/3	74	30	0	0	0	0	0	104	1795	0.6459
7/4	99	56	0	0	0	0	0	155	1950	0.7017
7/5	25	14	0	0	0	0	0	39	1989	0.7157
7/6	0	0	0	26	0	0	0	26	2015	0.7251
7/7	1	0	0	7	0	0	0	8	2023	0.7280
7/8	15	4	0	5	0	0	1	25	2048	0.7370
7/9	58	25	0	0	0	0	0	83	2131	0.7668
7/10	17	14	0	0	0	0	0	31	2162	0.7780
7/11	60	30	0	0	0	0	0	90	2252	0.8104
7/12	25	5	0	0	0	0	0	30	2282	0.8212
7/13	4	4	0	0	0	2	1	11	2293	0.8251
7/14	11	10	0	8	1	0	0	30	2323	0.8359
7/15	49	18	0	0	0	0	0	67	2390	0.8600

-continued-

APPENDIX 2. —(Page 2 of 2)

	Video			ASL		Ad-Clip				
Date	Male	Female	Unknown Sex	Male	Female	Male	Female	Daily Total	Daily Cumulative	Cumulative Proportion
7/16	26	7	0	0	0	0	0	33	2423	0.8719
7/17	12	4	0	0	0	0	0	16	2439	0.8777
7/18	23	22	0	0	0	0	0	45	2484	0.8938
7/19	7	0	0	0	0	0	0	7	2491	0.8964
7/20	6	0	0	4	1	0	1	12	2503	0.9007
7/21	10	10	0	4	0	0	0	24	2527	0.9093
7/22	9	4	1	0	0	0	0	14	2541	0.9144
7/23	22	10	0	0	0	0	0	32	2573	0.9259
7/24	14	7	0	0	0	0	0	21	2594	0.9334
7/25	10	1	0	0	0	0	0	11	2605	0.9374
7/26	10	5	0	0	0	0	0	15	2620	0.9428
7/27	16	2	0	6	0	0	0	24	2644	0.9514
7/28	15	12	0	0	0	0	0	27	2671	0.9611
7/29	14	3	0	0	0	0	0	17	2688	0.9673
7/30	10	2	0	0	0	0	0	12	2700	0.9716
7/31	8	2	0	0	0	0	0	10	2710	0.9752
8/1	7	2	0	0	0	0	0	9	2719	0.9784
8/2	10	1	0	0	0	0	0	11	2730	0.9824
8/3	5	2	0	0	0	0	0	7	2737	0.9849
8/4	5	1	0	0	0	0	0	6	2743	0.9870
8/5	5	0	0	0	0	0	0	5	2748	0.9888
8/6	6	1	0	0	0	0	0	7	2755	0.9914
8/7	1	2	0	0	0	0	0	3	2758	0.9924
8/8	2	1	0	0	0	0	0	3	2761	0.9935
8/9	1	1	0	0	0	0	0	2	2763	0.9942
8/10	2	0	0	0	0	0	0	2	2765	0.9950
8/11	3	0	0	0	0	0	0	3	2768	0.9960
8/12	3	0	0	0	0	0	0	3	2771	0.9971
8/13	2	0	0	0	0	0	0	2	2773	0.9978
8/14	0	0	0	0	0	0	0	0	2773	0.9978
8/15	3	0	0	0	0	0	0	3	2776	0.9989
8/16	1	0	0	0	0	0	0	1	2777	0.9993
8/17	0	0	0	0	0	0	0	0	2777	0.9993
8/18	0	0	0	0	0	0	0	0	2777	0.9993
8/19	0	0	0	0	0	0	0	0	2777	0.9993
8/20	1	0	0	0	0	0	0	1	2778	0.9996
8/21	0	0	0	0	0	0	0	0	2778	0.9996
8/22	0	0	0	0	0	0	0	0	2778	0.9996
8/23	0	0	0	0	0	0	0	0	2778	0.9996
8/24	1	0	0	0	0	0	0	1	2779	1.0000
Total	1756	818	10	144	37	6	8			

APPENDIX 3. —Daily counts of salmon and resident fish species passing through the Funny River weir, Alaska, 2006. Shaded areas represent a period of 24 h video loss spanning two days as a result of high water.

Date	Rainbow Trout	Dolly Varden	Whitefish	Sockeye Salmon	Pink Salmon	Chum Salmon	Coho Salmon	Total
6/1	1	1	2	0	0	0	0	4
6/2	0	2	0	1	0	0	0	3
6/3	1	3	1	0	0	0	0	5
6/4	0	0	0	0	0	0	0	0
6/5	0	1	0	0	0	0	0	1
6/6	0	2	0	0	0	0	0	2
6/7	2	0	1	0	0	0	0	3
6/8	1	1	1	0	0	0	0	3
6/9	1	5	0	0	0	0	0	6
6/10	0	4	0	0	0	0	0	4
6/11	1	1	0	0	0	0	0	2
6/12	0	0	1	0	0	0	0	1
6/13	1	1	0	0	0	0	0	2
6/14	2	3	0	0	0	0	0	5
6/15	2	0	0	1	0	0	0	3
6/16	0	1	0	1	0	0	0	2
6/17	0	1	0	0	0	0	0	1
6/18	0	2	0	0	0	0	0	2
6/19	2	3	0	0	0	0	0	5
6/20	2	1	0	0	0	0	0	3
6/21	1	1	0	0	0	0	0	2
6/22	0	1	0	0	0	0	0	1
6/23	0	3	1	0	0	0	0	4
6/24	3	3	0	0	1	0	0	7
6/25	1	2	0	0	0	0	0	3
6/26	3	2	0	1	1	0	0	7
6/27	0	1	0	0	0	0	0	1
6/28	3	3	0	1	0	0	0	7
6/29	1	0	0	0	0	0	0	1
6/30	0	1	0	1	0	0	0	2
7/1	1	2	1	0	1	0	0	5
7/2	2	3	0	2	2	0	0	9
7/3	0	1	0	3	5	0	0	9
7/4	4	2	0	1	2	0	0	9
7/5	3	2	0	3	1	0	0	9
7/6	0	0	0	0	0	0	0	0
7/7	1	0	0	0	0	0	0	1
7/8	0	0	0	0	0	0	0	0
7/9	0	0	0	0	2	0	0	2
7/10	0	7	0	1	0	0	0	8
7/11	0	1	0	3	0	0	0	4
7/12	1	4	0	6	2	0	0	13
7/13	0	0	0	0	0	0	0	0
7/14	0	2	0	0	0	0	0	2
7/15	2	10	0	0	0	0	0	12
7/16	1	10	0	0	1	0	0	12
7/17	1	15	0	0	0	0	0	16

-continued-

APPENDIX 3. —(Page 2 of 3)

Date	Rainbow Trout	Dolly Varden	Whitefish	Sockeye Salmon	Pink Salmon	Chum Salmon	Coho Salmon	Total
7/18	2	23	1	0	0	0	0	26
7/19	0	20	0	3	2	0	0	25
7/20	0	0	0	0	0	0	0	0
7/21	0	0	0	0	1	0	0	1
7/22	2	12	0	1	2	0	0	17
7/23	1	20	0	0	1	0	0	22
7/24	2	39	0	2	4	0	0	47
7/25	0	40	0	0	5	0	0	45
7/26	0	20	1	0	3	0	0	24
7/27	1	10	0	2	5	0	0	18
7/28	4	67	0	2	5	0	0	78
7/29	2	94	1	2	1	0	0	100
7/30	0	51	0	3	3	0	0	57
7/31	2	29	1	10	17	0	0	59
8/1	0	56	0	7	16	1	1	81
8/2	0	27	0	3	11	0	0	41
8/3	0	51	0	5	10	0	0	66
8/4	0	24	0	3	8	0	1	36
8/5	0	33	1	4	13	0	1	52
8/6	1	37	0	1	27	0	0	66
8/7	0	59	0	4	19	0	2	84
8/8	0	47	0	5	11	0	0	63
8/9	1	79	0	6	22	0	1	109
8/10	0	43	0	6	10	0	0	59
8/11	0	120	0	7	15	0	10	152
8/12	0	136	0	9	26	0	23	194
8/13	0	89	0	7	10	0	35	141
8/14	0	44	0	5	6	0	9	64
8/15	1	54	0	3	6	0	0	64
8/16	1	104	1	2	13	1	11	133
8/17	0	2	0	0	1	0	25	28
8/18	0	64	0	3	8	1	84	160
8/19	0	158	0	1	18	0	57	234
8/20	0	62	0	1	6	0	43	112
8/21	0	26	0	4	3	0	20	53
8/22	0	6	0	2	0	0	27	35
8/23	0	42	0	2	6	0	93	143
8/24	0	15	0	0	5	0	23	43
8/25	0	24	0	1	1	0	93	119
8/26	0	2	0	0	1	0	12	15
8/27	0	3	0	0	1	0	32	36
8/28	0	31	0	1	1	0	185	218
8/29	0	36	0	1	2	0	42	81
8/30	1	27	0	1	0	0	55	84
8/31	1	30	0	2	3	0	47	83
9/1	0	31	0	3	2	0	80	116
9/2	0	29	0	0	3	0	54	86
9/3	0	36	0	0	3	0	56	95

-continued-

APPENDIX 3. —(Page 3 of 3)

Date	Rainbow Trout	Dolly Varden	Whitefish	Sockeye Salmon	Pink Salmon	Chum Salmon	Coho Salmon	Total
9/4	0	24	0	2	1	0	41	68
9/5	0	24	0	0	3	0	52	79
9/6	0	22	0	0	4	0	37	63
9/7	0	9	0	1	2	0	4	16
9/8	0	11	0	1	8	1	34	55
9/9	0	45	0	0	8	0	113	166
9/10	0	40	0	0	10	0	71	121
9/11	0	29	0	1	10	0	64	104
9/12	0	25	0	0	2	0	18	45
9/13	0	16	0	1	6	0	30	53
9/14	0	15	0	0	4	0	31	50
9/15	1	19	0	0	4	0	58	82
9/16	2	22	0	0	5	0	64	93
9/17	0	19	0	0	1	0	39	59
9/18	0	7	0	0	0	0	18	25
9/19	1	3	0	0	1	0	5	10
9/20	0	9	0	0	0	0	11	20
9/21	0	6	0	0	0	0	6	12
9/22	0	7	0	0	0	0	29	36
9/23	0	9	0	0	2	0	34	45
9/24	1	4	0	2	1	0	8	16
9/25	0	1	0	0	0	0	5	6
9/26	0	1	0	0	1	0	1	3
9/27	0	3	0	0	0	0	4	7
9/28	0	1	0	0	1	0	7	9
9/29	0	3	0	0	0	0	3	6
9/30	0	1	0	0	0	0	0	1
10/1	1	2	0	1	0	0	0	4
10/2	0	0	0	0	0	0	0	0
Total	72	2537	14	158	428	4	1909	5122